

TRANSLATION FOR JP 2001-118682

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the organic electroluminescence (organic electroluminescence) element which used organic materials for the luminous layer. An organic EL device has the features, such as spontaneous light and a high speed response, and application to a flat-panel display is expected.

[0002]

[Description of the Prior Art] In an organic EL device, it is desired for the light quantity to the current amount injected into the element to be comparatively (luminous efficiency) large. The luminous efficiency of an organic EL device is proportional to the fluorescence quantum yield of a luminescent material. Here, a fluorescence quantum yield is expressed with N_1/N_0 when the number of the molecules which show a fluorescence among N_0 and the excited molecule, and return the total molecularity excited by the first excitation singlet state to a ground state is made into N_1 . Since the conventional luminescent material did not have the large fluorescence quantum yield enough, its luminous efficiency of the organic EL device was low.

[0003] In order to produce a full color display using an organic EL device, it is necessary to arrange on a panel blue, green, and the pixel that carries out luminescence of the red three primary colors. The following three kinds of methods are proposed as a method of full-colorizing.

[0004] The 1st method is a method which arranges blue, green, and three kinds of EL elements that emit each red light. The 2nd method is a method which uses a light filter for the white light emitted from the EL element which carries out white light, and is colored it. The 3rd method is a method which carries out the convert colors of the light from the EL element which carries out blue light to green and red by the color conversion layer using firefly luminescence. Also in

which method, the EL element which emits the light of a blue wavelength band is needed.

[0005]

[Problem(s) to be Solved by the Invention]The purpose of this invention is to provide the organic EL device [fluorescence amount child efficiency is large, and] which can perform blue light.

[0006]

[Means for Solving the Problem]According to one viewpoint of this invention, 1,3,6,8-tetraphenylpyrene, An alkyl derivative of 1,3,6,8-tetraphenylpyrene, a cycloalkyl derivative of 1,3,6,8-tetraphenylpyrene, And an organic electroluminescence element which has a luminous layer which was chosen from a group which consists of an aryl derivative of 1,3,6,8-tetraphenylpyrene, and which includes the 1st one organic materials at least, and an electrode of a couple for pouring an electron and an electron hole into said luminous layer is provided.

[0007]In 1,3,6,8-tetraphenylpyrene and an above-mentioned 1,3,6,8-tetraphenyl pyrene derivative, excitation state La (state where oscillator strength to transition to a ground state is large) of a molecule forms the first excitation singlet state. For this reason, a big fluorescence quantum yield is expected. Luminous efficiency of an organic EL device can be raised by using such materials as a luminescent material.

[0008]

[Embodiment of the Invention]In the organic EL device by working example of this invention, 1,3,6,8-tetraphenylpyrene is used as a luminescent material. The molecular structure type of 1,3,6,8-tetraphenylpyrene is shown in drawing 1. The hydrogen atom of the position of 1, 3, 6, and 8 of pyrene is replaced by the phenyl group. Invention-in-this-application persons newly discovered that 1,3,6,8-tetraphenylpyrene had a big fluorescence quantum yield. It explains comparing with the fluorescence quantum yield of pyrene hereafter the Reason the fluorescence quantum yield of 1,3,6,8-tetraphenylpyrene is large.

[0009]The energy state figure of the pyrene molecule for which it asked by calculation which used the molecular orbital method for the left-hand side of drawing 2 is shown. The two excitation states La and Lb exist on ground state S_0 . Excitation state La is equivalent to the state where the oscillator strength to the transition to a ground state is large, and the excitation state Lb is equivalent to the state where the oscillator strength to the transition to a ground state is small. In the case of pyrene, the excitation state Lb is located under excitation state La. That is, the excitation state Lb forms the first excitation singlet state (S_1 state), and excitation state La forms the second excitation singlet state (S_2 state). For this reason, if a pyrene molecule is excited, the transition to ground state S_0 from the excitation state Lb will become superior.

[0010]The energy state figure of the 1,3,6,8-tetraphenyl pyrene molecule for which it asked by

calculation which used the molecular orbital method for the right-hand side of drawing 2 is shown. If the position of 1, 3, 6, and 8 of a pyrene molecule is replaced by a phenyl group, an electronic state will change and excitation state La with large oscillator strength to the transition to a ground state will fall. The decrease amount of excitation state La becomes large, so that the influence on the electronic state by the number of substituents and a substituent is great. On the other hand, the excitation state Lb with small oscillator strength to the transition to a ground state is not greatly influenced by introduction of a substituent. In the case of a 1,3,6,8-tetraphenyl pyrene molecule, excitation state La is located under the excitation state Lb. That is, excitation state La forms an S_1 state, and the excitation state Lb forms an S_2 state. For this reason, if a 1,3,6,8-tetraphenyl pyrene molecule is excited, the transition to ground state S_0 from excitation state La will become superior.

[0011]When a molecule changes from the excitation state Lb to ground state S_0 , firefly luminescence does not happen easily. On the other hand, when a molecule changes from excitation state La to ground state S_0 , firefly luminescence happens easily. For this reason, when a pyrene molecule returns from an excitation state to a ground state, firefly luminescence does not happen easily, and when a 1,3,6,8-tetraphenyl pyrene molecule returns from an excitation state to a ground state, firefly luminescence happens easily. That is, the fluorescence quantum yield of a 1,3,6,8-tetraphenyl pyrene molecule is larger than the fluorescence quantum yield of a pyrene molecule. For this reason, it is thought by using a 1,3,6,8-tetraphenyl pyrene molecule as a luminescent material that luminous efficiency can be raised.

[0012]The energy of the excitation states La and Lb of a molecule can be predicted by calculation which used the molecular orbital method. Invention-in-this-application persons calculated the energy of the excitation states La and Lb about various pyrene derivatives. In 1,3,6,8-tetraisopropylpyrene, 1,3,6,8-tetracyclo hexylpyrene, and 1,6-diphenylpyrene, the excitation state Lb formed the S_1 state.

[0013]This calculation result shows that what was replaced especially by four phenyl groups among pyrene derivatives shows a big fluorescence quantum yield. Even if it replaces the hydrogen atom of the phenyl group of a 1,3,6,8-tetraphenyl pyrene molecule by the alkyl group, the cycloalkyl group, and an aryl group, it seems that there is little influence of the electronic state on a molecule. Therefore, as a luminescent material, big fluorescence amount child efficiency will be obtained, even if it uses these 1,3,6,8-tetraphenyl pyrene derivatives. The molecular structure type of these derivatives is shown in drawing 3. R1-R4 of drawing 3 are a hydrogen atom, an alkyl group, a cycloalkyl group, or an aryl group.

[0014]Next, the result of having measured the fluorescence quantum yield of 1,3,6,8-tetraphenylpyrene is explained. Measurement of the fluorescence quantum yield was

performed by the method indicated to the 80th page from the 76th page of Taiji Nishikawa, Keizo Hiraki work, and "fluorescence and a phosphorimetry method" (KYORITSU SHUPPAN, 1984). The used standard substance is a cyclohexane solution (fluorescence quantum yield 0.31) of anthracene.

[0015]The cyclohexane solution of 3×10^{-7} M of anthracene and 1,3,6,8-tetraphenylpyrene was produced, and fluorescence amount child efficiency was measured in the atmosphere which carried out the nitrogen purge. 1,3,6,8-tetraphenylpyrene can be obtained from Pfaltz&Bauer (U.S.), for example. The fluorescence amount child efficiency of 1,3,6,8-tetraphenylpyrene was 0.9. The fluorescence amount child efficiency of the pyrene measured in the similar way was 0.3. Thus, big fluorescence amount child efficiency can be obtained by using 1,3,6,8-tetraphenylpyrene as a luminescent material.

[0016]Next, with reference to drawing 4 - drawing 5, the lamination type organic EL device using 1,3,6,8-tetraphenylpyrene is explained.

[0017]Drawing 4 shows the sectional view of a lamination type organic EL device. The positive electrode layer 2 which consists of indium tin oxide (ITO) is formed on the surface of the glass substrate 1. On the positive electrode layer 2, the 50-nm-thick electron hole transporting bed 3, the 20-nm-thick luminous layer 4, the 30-nm-thick electron transport layer 5, and the 50-nm-thick negative electrode layer 6 are laminated by this turn.

[0018]The electron hole transporting bed 3 is formed by N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl 4,4'-diamine (TPD). The molecular structure type of TPD is shown in drawing 5 (A). The luminous layer 4 is formed by 1,3,6,8-tetraphenylpyrene. The electron transport layer 5 is formed by 3-(4-biphenyl)-4-phenyl-5-(4-t-butylphenyl)-1,2,4-triazole (TAZ). The molecular structure type of TAZ is shown in drawing 5 (B). As for the negative electrode layer 6, lithium content is formed by 0.5% of the weight of an aluminium-lithium alloy.

[0019]Hereafter, the formation method of these layers is explained briefly. First, water, acetone, and isopropyl alcohol wash the substrate with which the positive electrode layer 2 was formed. Each class is formed with vacuum deposition under the conditions which set the pressure to 1×10^{-6} Torr (1.3×10^{-4} Pa), and made substrate temperature the room temperature. It vapor-deposits using a mask so that a part of positive electrode layer 2 may be exposed.

[0020]By DC power supply 7, the voltage of 10V was impressed between the negative electrode layer 6 and the positive electrode layer 2. Light emitting luminance in case

luminescence starting potential is 6V and impressed electromotive force is 10V was $680\text{cd}/\text{m}^2$, and the luminescent color was blue.

[0021]Next, various modifications of above-mentioned working example are explained. The laminated structure of the EL element by a modification is the same as that of the structure shown in drawing 4, and differs from the case where the material which forms the luminous

layer 4 is above-mentioned working example.

[0022]In the 1st modification, the luminous layer 4 contains 1,3,6,8-tetraphenylpyrene as the main ingredients, and contains perylene as an accessory constituent. The molecular structure type of perylene is shown in drawing 6 (A). The luminous layer 4 is formed when the evaporation rate ratio of 1,3,6,8-tetraphenylpyrene and perylene vapor-deposits on the conditions used as 100:1 using a separate deposition source.

[0023]The energy of an S_1 state of perylene is lower than that of 1,3,6,8-tetraphenylpyrene.

The fluorescence amount child efficiency of perylene is larger than that of 1,3,6,8-tetraphenylpyrene. In such composition, the excitation energy of the luminous layer 4 moves to an accessory constituent from the main ingredients, and firefly luminescence arises from an accessory constituent. For this reason, improvement in luminous efficiency is expectable. The luminescent color can be adjusted.

[0024]When the EL element of the structure shown in drawing 4 was actually produced and the luminescent characteristic was measured, luminescence starting potential was 4V, light emitting luminance in case impressed electromotive force is 10V was $1300\text{cd}/\text{m}^2$, and the luminescent color was blue.

[0025]In the 1st modification, although perylene was used as an accessory constituent of the luminous layer 4, the material of others in which the energy of an S_1 state is smaller than the energy of an S_1 state of the 1,3,6,8-tetraphenylpyrene which is the main ingredients may be used. Probably, about 0.01-10 mol % will be suitable for the addition of an accessory constituent. In order to aim at improvement in luminous efficiency, it is preferred to choose an accessory constituent so that the fluorescence quantum yield of an accessory constituent may become larger than that of the main ingredients.

[0026]For example, acridone may be chosen as an accessory constituent. The molecular structure type of acridone is shown in drawing 6 (B). When using acridone as an accessory constituent, the luminous layer 4 is formed when the evaporation rate ratio of 1,3,6,8-tetraphenylpyrene and acridone vapor-deposits on the conditions used as 100:1 using a separate deposition source. When the EL element of the structure shown in drawing 4 was produced and the luminescent characteristic was measured, luminescence starting potential was 4V, light emitting luminance in case impressed electromotive force is 10V was $1150\text{cd}/\text{m}^2$, and the luminescent color was blue.

[0027]In the 2nd modification, the luminous layer 4 contains TAZ as the main ingredients, and contains 1,3,6,8-tetraphenylpyrene as an accessory constituent. The luminous layer 4 is formed when the evaporation rate ratio of 1,3,6,8-tetraphenylpyrene and TAZ vapor-deposits on the conditions used as 1:100 using a separate deposition source.

[0028]The energy of an S_1 state of TAZ is higher than the energy of an S_1 state of 1,3,6,8-tetraphenylpyrene. For this reason, the excitation energy of TAZ moves to 1,3,6,8-tetraphenylpyrene, and 1,3,6,8-tetraphenylpyrene shows a fluorescence. In the 2nd modification, there is little content of the 1,3,6,8-tetraphenylpyrene of the luminous layer 4. For this reason, 1,3,6,8-tetraphenyl pyrene molecule distance becomes long, and the adverse effect by the interaction of a molecule decreases. Thereby, improvement in luminous efficiency is expectable. When the EL element of the structure shown in drawing 4 was produced and the luminescent characteristic was measured, luminescence starting potential was 4V, light emitting luminance in case impressed electromotive force is 10V was $1260\text{cd}/\text{m}^2$, and the luminescent color was blue.

[0029]In the 2nd modification, although TAZ was used as the main ingredients of the luminous layer 4, the energy of an S_1 state may use the material of bigger others than the energy of an S_1 state of 1,3,6,8-tetraphenylpyrene as the main ingredients. Good amorphous films can be formed as the main ingredients, and the material which has the suitable charge transport characteristic is suitable.

[0030]For example, TPD may be used as the main ingredients of the luminous layer 4. In this case, the luminous layer 4 is formed when the evaporation rate ratio of 1,3,6,8-tetraphenylpyrene and TPD vapor-deposits on the conditions used as 1:100 using a separate deposition source. When the EL element of the structure shown in drawing 4 was produced and the luminescent characteristic was measured, luminescence starting potential was 4V, light emitting luminance in case impressed electromotive force is 10V was $1190\text{cd}/\text{m}^2$, and the luminescent color was blue.

[0031]When the main ingredients of the luminous layer 4 were set to TAZ and an accessory constituent was made into pyrene for comparison, $160\text{cd}/\text{m}^2$ and the luminescent color had green light emitting luminance in case luminescence starting potential is 7V and impressed electromotive force is 10V. Rather than the case where pyrene is used as a luminescent material, the direction at the time of using 1,3,6,8-tetraphenylpyrene can obtain high light emitting luminance.

[0032]Although this invention was explained in accordance with working example above, this invention is not restricted to these. For example, probably, it will be obvious to a person skilled in the art for various change, improvement, combination, etc. to be possible.

[0033]

[Effect of the Invention]As explained above, according to this invention, an EL element with high luminous efficiency is producible by using 1,3,6,8-tetraphenylpyrene etc. as a luminescent material.

[Translation done.]